Geology, Stratigraphy & Geochemical Characteristics of Potential Oil Shale

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Potential Oil Shale & Shale Gas Basins of India

- Assam-Arakan
- Gondwana
- Rajasthan
- Krishna- Godavari
- Cambay
- Vindhyan
- Bengal
- Cauvery

What is oil shale

- Fine grained sedimentary rocks containing relatively large amount of organic matter from which significant quantities of shale oil and combustible gas can be extracted.
- Oil shales range in age from Cambrian to Tertiary
- Total world resources of oil shale are conservatively estimated at 2.6 trillion barrels
- Studies have shown that similar rocks with most of their oil generating potential are preserved in Northeast India interbedded with the tertiary coal.
- The estimated in-place oil reserve of these carbonaceous shales is greater than 15 billion tons.
- Oil shales contain no liquid oil in their natural state and must be retorted at very high temperatures to convert the solid kerogen to liquid Hydrocarbons
- Retorting is an energy intensive process in which the rock is heated to 450- 550°C in the absence of oxygen

OIL SHALES OCCURRENCE IN INDIA

- Carbonaceous shale of Oligocene age occurs in association with Tertiary Coal in Assam and neighboring areas of Arunachal Pradesh
- The coal-shale unit occurs as outcrops towards south of the oilfields in a region called the Belt of Schuppen
- The presence of coal and organic rich shale has been recorded in the subsurface from wells drilled for oil
- The coal-shale unit was probably deposited in a regressive phase in backwater lagoons or brackish water swamps on a prograding delta complex

Structural map of Assam-Arakan Basin

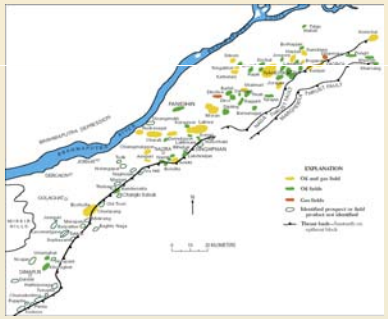
What is Shale Gas?

- Shale gas is gas contained in adsorbed form in the micro-pores and micro-fractures of shale which is a sedimentary rock. The gas is mostly of thermogenic origin but cases of biogenic sources are also reported.
- The shale gas exploration in India is relatively new but rapidly gaining momentum, as India has huge shale deposits. The shales in Vindhyan, Gondwana, Cambay, Rajasthan and other sedimentary basins have been/are being field experimented. The initial results are encouraging and are at par with US producing shales.
- The shale gas production pressures are generally low but length of production period compensates by volume.

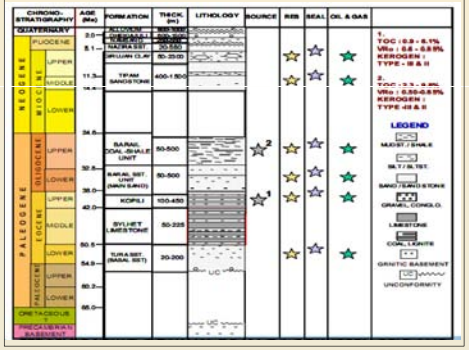
Geological parameters for Shale gas evaluation

1. Organic matter richness
2. Thickness &area extent
3. Thermal maturity
4. Mineralogy
5. Faults & Fractures
6. Gas content
7. Storage
8. Brittleness

Oil, gas fields & identified Prospects in Assam geologic province



Stratigraphic succession of Upper Assam Shelf

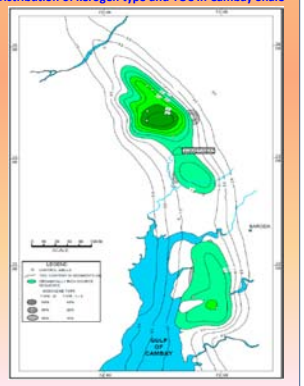


Rock-Eval Results from Barail Fm. In selected wells

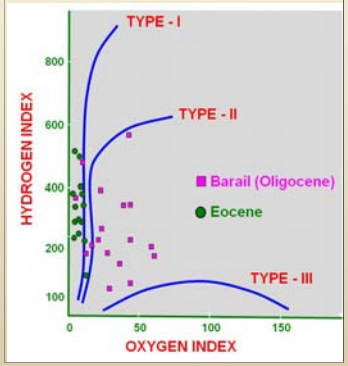
Sample Code	TOC (%)	S1 (mg/g)	S2 (mg/g)	Tmax (°C)	HI	OI
Mta-1	77.02	8.76	288.38	435	374	5
Mta-2	64.74	8.15	255.24	431	394	22
Mta-3	66.00	7.91	268.03	433	486	12
Mak-1	15.99	1.19	34.37	436	214	59
Dli-1	38.96	6.89	222.43	425	570	43
Trp-1	12.75	2.62	44.73	436	350	43
Trp-2	14.89	2.54	53.75	432	360	-

Geological map of Cambay basin

Distribution of kerogen type and TOC in Cambay Shale



HI vs. OI Plot

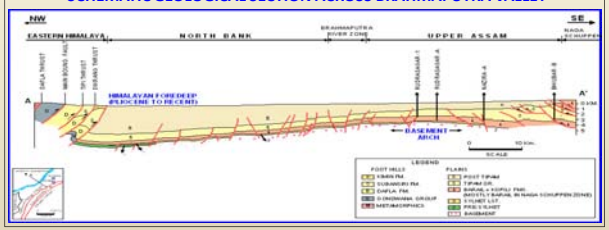


Characteristics of Barail Formations

BARAIL (Oligocene)

- Average vitrinite reflectance in oil shale ranges from 0.5 to 0.7%.
- Rock-eval Tmax values are less than 435°c Indicating low thermal maturity
- The organic matter is predominantly type-II +type III
- Biomarker ratios indicate a dominance of land plant derived kerogen : preponderance of C29 ααα 20R steranes and high hopane/sterane ratio
- Sulfur content is high : 1.5 to 5%

SCHEMATIC GEOLOGICAL SECTION ACROSS BRAHMAPUTRA VALLEY



CONCLUSIONS

Oil shales in India mostly occur in Assam- Aarkan Basin and have resource potential of 15 billion tons of in place oil. DGH India& BRGM, France are carrying out geo-scientific studies of these shales and award of blocks for exploration and production may start from 2012 onwards.

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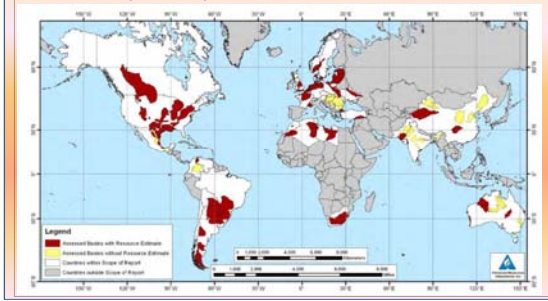
Map of 48 major shale basins in 32 countries

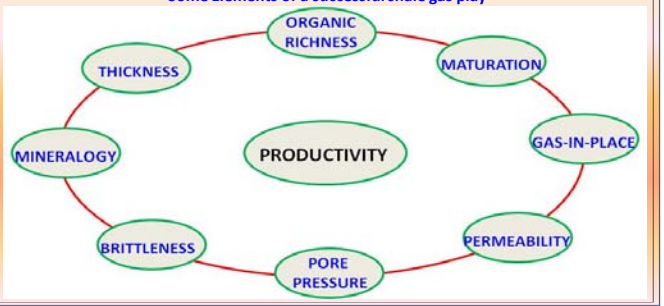


Shale Gas Production Methodology

•Shale's have low permeability (~ 2 md) and gas does not flow easily through this rock. However, in the 1990s a new drilling technology emerged. A tight shale deposit could be cracked open by injecting water into wells at high pressure. When the water injection stopped, the cracks closed again. But then technologist hit on the idea of pumping water mixed with sand. The sand kept cracks partially open when water injection stopped, increasing permeability and gas flow.

*A sedimentary rock deposit has a limited depth but very wide area (sometimes hundreds of square miles). Traditional vertical drilling into a deposit 20 meters deep can yield gas production from a zone of just 20 meters. But new techniques have facilitated horizontal drilling. This makes possible horizontal wells running hundreds of meters long through shale strata, greatly increasing the production zone of each well. Horizontal drilling plus sand cracking have revolutionized the economics of shale gas in the US, and made it a developing industry.

Some Elements of a successful shale gas play



R&D Status of Shale Gas Exploration in India

• ONGC & GSPC are the frontrunner in shale gas exploration. ONGC has tied with Schlumberger to explore shale gas in Gondwana and Cambay basins, India.

• The target areas in Gondwana are organic rich shale horizons associated with unmineable coal seams.

• In Cambay basin, the Tarapur and Cambay shale formations are being explored for shale gas potential.

ONGC ventures into shale gas exploration

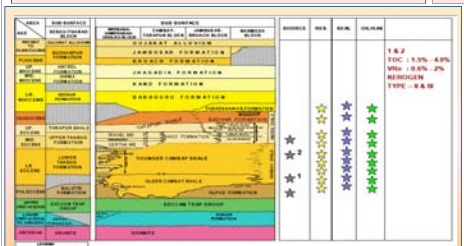
• ONGC has drilled first shale gas well in Damodar Valley, West Bengal through Permian Shale of about 700 meters thick. The well is targeted to a depth of 2000 meters.

•ONGC plans to drill three more wells in the Valley by March 2012.

• Damodar Valley is a coal field area and Ist well is drilled near Durgapur in Ranigunj coal field of Damodar Valley.

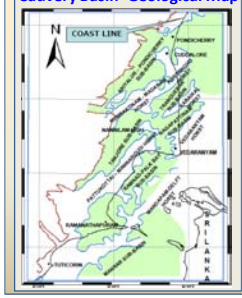
Indian Shale Reservoir Property versus Barnett, USA

PROPERTY	USA	INDIA	
	BARNETT	TERTIARY – CAMBAY	PERMIAN - GONDWANA
Depth (m)	2000-2500	1000-2000	1200-2200
Net Thickness (m)	15-60	100-600	30-150
TOC %	4.5	2.3-5.4%	4.0-6.0
Vitrinite Reflectance (%)	1.0-1.3	0.6-1.1	1.2-1.4
Permeability Thickness [Kh(md-ft)]	0.01-2	NA	NA
Gas content (M3/ton)	8.0-10	2.5-4.5	5.0-8.0
Pressure Gradient (psi/ft)	0.43-0.44	0.43	0.43-0.47
Recovery Factor (%)	8-15	NA	NA

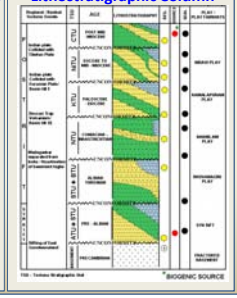


Generalised stratigraphy of Cambay Basin

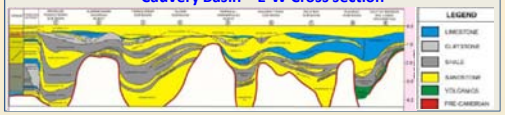
Cauvery Basin- Geological Map



Lithostratigraphic Column



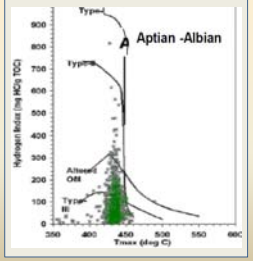
Cauvery Basin – E-W Cross section



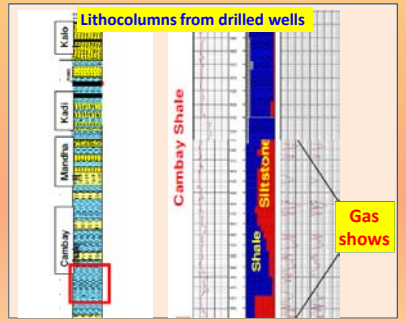
Characteristics of shales of Cauvery Basin

Formation	Thickness(m)	TOC (%)	VRo (%)	Kerogen Type
Ariyalur-Pondicherry	1500	0.31-2.78	1.15	II & III
Tranquebar	2000	0.31-4.76	0.65-0.79	II & III
Nagapattinam	1500	1.68	0.45-0.34	II & III
Mannar	2000	1.5	1.0-1.12	II & III

HI vs. OI Plot

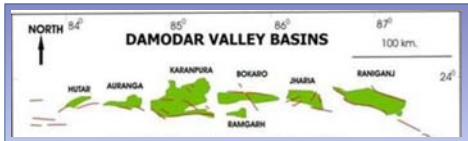


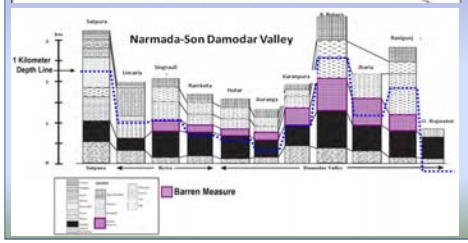
Lithocolumns from drilled wells



Characteristics of Shales of Cambay Basin

Formation	Thickness(m)	TOC (%)	VRo (%)	Kerogen Type
Olpad	340-2700	1.5-4.0	0.75	II & III
Older Cambay Shale	500-1900	1.5-4.0	0.75-0.85	II & III
Younger Cambay Shale	520-1500	1.0-4.0	0.75-0.85	II & III
Kalol	200-300		0.75	II & III
Tarapur	60-400		0.53	





Damodar Valley – Barren Measures		
Gross Area (mi²)		9100
Formation /Age		Barren Measure / Permo Triassic
Prospective area (mi²)		1080
Thickness (ft)	Interval	0-2100
	Organically Rich	1050
	Net	368
Depth (ft)	Interval	3820-6560
	Average	4920
Reservoir Pressure		Moderately Over pressured
Average TOC (wt %)		4.5%
Thermal Maturity (Ro%)		1.20%
Clay Content		High
Resource	GIP concentration (BCF /mi²)	123
	Risked GIP (TCF)	33
	Risked Recoverable (TCF)	7

CONCLUSIONS

- India has vast resources of shale gas(60 tcf recoverable?) and has taken major initiatives towards exploration and development of the same.
- The basin wise assessment is in progress and Directorate General of Hydrocarbons have planned to carve out exploration blocks for commercial exploitation of shale gas.
- Exploration activities have been started in Cambay and Damodar valley basins.